Consultation Workshop on

"Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal"

22 February 2013, Inaruwa, Sunsari

<u>Organized by:</u>

Nepal Development Research Institute (NDRI),

Pulchowk, Lalitpur, Nepal

<u>Supported by:</u>

Climate Development Knowledge Network (CDKN)

Global Change System for Analysis, Research and Training (START)

1 Location Description

The consultative workshop on *"Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal"* was held Inaruwa - the district capital of Sunsari. The Inaruwa Municipality lies about 24 km north-east of the Koshi Barrage and about 16 km north-west of Biratnagar Municipality. The villages of Sunsari (lower part of the Koshi Basin - Pashim Kusaha, Laukahi, Haripur, Shreepur) are the most affected areas in 2008 Koshi Flood. Since, this study aims to involve the local people and stakeholders in the identifying the local issues, opinions and experiences to make the study pragmatic, Inaruwa is considered as suitable location for the location. **Figure 1-1** shows the location map of the workshop venue - Inaruwa Municipality.

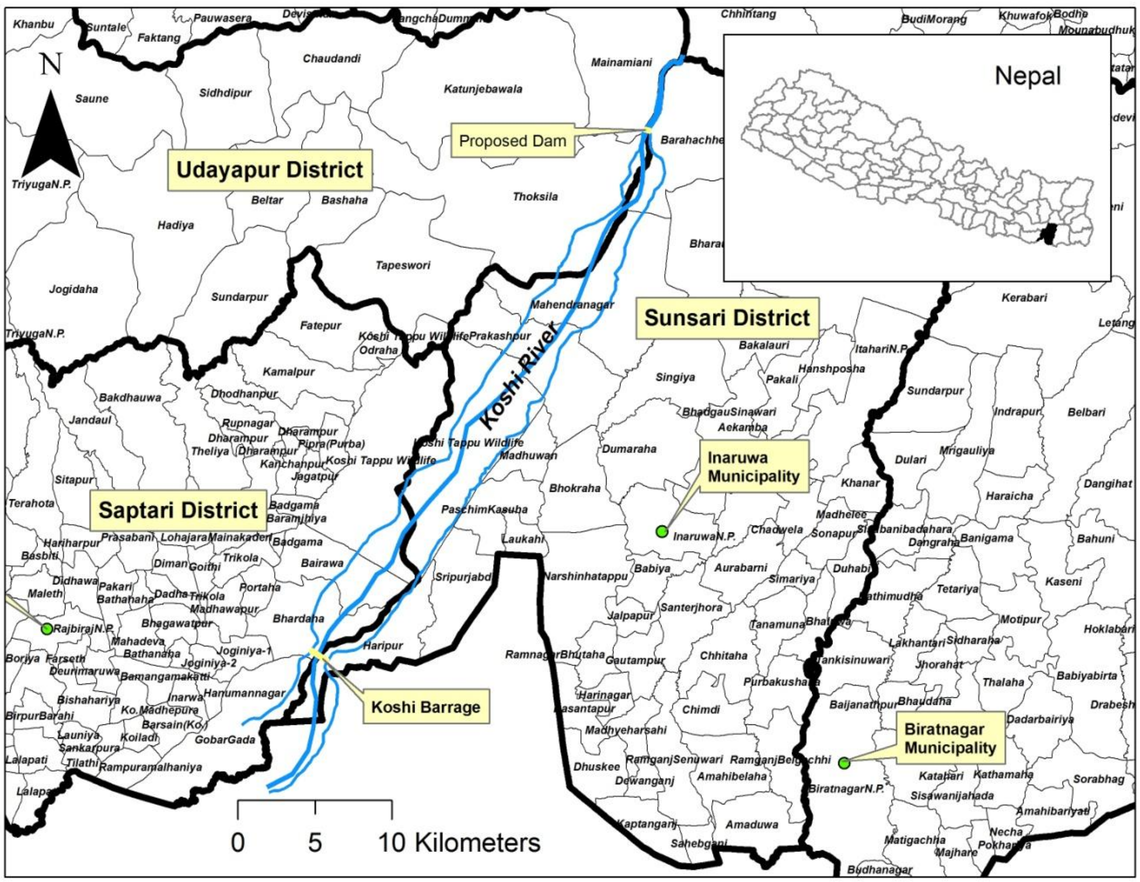


Figure 1-1: Location Map of Workshop-Venue: Inaruwa Municipality

2 Participation in the Consultative Workshop

There was enthusiastic participation of representatives from governmental and international/ national non-governmental organizations, educational institutes, concerned stakeholders and local communities in the consultative workshop. There were altogether 23 participants in the workshop including the project members. The list of participants is presented in Annex I.

3 Consultative Workshop Module

The workshop was conducted for one day. The workshop was divided into three sessions: Inaugural Session, Technical Session and Feedback/ Consultation Session.

3.1 Inaugural Session:

This session was formally opened by welcoming the chief guest -Mr. Jay Prakash Gupta, Campus Chief, Sunsari Multiple Campus; the chairperson - Dr. Jaya Kumar Gurung , Secretary, Nepal Development Research Institute and the Principal Investigator of this research- Dr. Laxmi Prasad Devkota, the Executive Director, Nepal Development Research Institute upon the dias. It was followed by warm welcome speech from the co-investigator of this project- Dr. Manjeshwori Singh, the treasurer of Nepal Development Research Institute. Then, the main features of the project and its objectives were presented by Dr. Devkota. It was then followed by important remarks from the chief guest. Later, this session was concluded by vote of thanks by the chairperson. The Master of Ceremony for the session was Ms. Anita Khadka, Research Associate, Nepal Development Research Institute.

3.1.1 Welcome Speech by Dr. Manjeshwori Singh, Co-investigator of this project and Treasurer of Nepal Development Research Institute

"Dear respectable Chairman - Dr. Jaya Kumar Gurung, today's Chief guest Mr. Jaya Prasad Gupta of Sunsari Multiple Campus, the principal investigator of this project - Dr. Laxmi Prasad Devkota, representatives of governmental and non-governmental organizations, concerned organizations and local communities!

Photograph 3-1 : Dr. Manjeshwori Singh giving the welcome speech

I heartily welcome and greet all of you in this one day workshop on "Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal" on behalf of Nepal Development Research Institute (NDRI). In current context, climate change has been important discussion issue in the world that has affected all the living beings. It has been observed that Climate Change has affected more in developing *countries like ours than the developed countries. Nepal is even more at risk because of poor infrastructures , the excessive rainfall in monsoon season, low rainfall in other months and other similar reasons.*

According to the study report by UNDP in 2004, Nepal stands 30th on the flood risk country among 200 countries. World Bank in 2005 has listed Nepal as one of the hotspots in world in terms of natural disasters. It is well-known that floods in Koshi River; which originates in China, flows through Terai of Nepal and meets Ganga River in Bihar; cause large damages to life and properties. Good example is the Koshi Flood in 2008 which caused huge destruction in Nepal and India. Therefore, to control the flood, to generate hydropower and to irrigate, the construction of the Koshi High Dam has been proposed. In this context, I would like to inform that this research will look into the possible impacts of Climate Change in the basin and also look into possible impacts of Koshi High Dam- especially focusing on the disaster risk reduction.

The main objective of today's workshop is to share what we have done till today and to have suggestions to move forward in the research. Therefore, with expectations of good suggestions and direction, I again welcome all of you. With this, I will conclude my few words. Thank you!"

3.1.2 Key notes from the introductory speech by Dr. Laxmi Prasad Devkota, the Principal Investigator of this project and the Executive Director of Nepal Development Research Institute

Dr. Laxmi Prasad Devkota first thanked all the representatives for accepting the invitation and participation in the workshop. Then, he introduced Nepal Development Research Institute and its objectives of conducting researches to aid the policy process in Nepal. He then introduced the research project - "Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal". He introduced the study team members to all the participants. He heartily thanked Climate Development Knowledge Network (CDKN) and Global Change System for Analysis, Research and Training (START) for their kind financial support in carrying out the research.

Photograph 3-2 : Dr. Laxmi Prasad Devkota giving the introductory speech

Before he explained in-depth about this research, he described importance of water resources in the socio-economic development of Nepal. He briefly discussed the possible impacts of climate variability and change in the hydrology of Nepal, thus making aware the group regarding the importance of researches in understanding the hydrology in such conditions. He further explained the importance of this workshop in bringing out the hidden problems present in the area; which won't be possible when designing the problem in remote distance like Kathmandu. Besides, he particularly emphasized the participants to provide suggestions or highlight key points that can be crucial in social survey, hence should be taken into account during study.

Dr. Laxmi Prasad Devkota then explained the objectives of the study. He pointed out that the objective of this study is to access the impact of the climate variability and change in the present and future development in Koshi River Basin and disaster risk reduction in the study area. He further elaborated the components of the study namely:

a. Advancing knowledge on climate change impact on water resources: Dr. Devkota pointed out that this study deals with the hydro-meteorological diagnostics; and hydrological (including the Snow-Runoff Modeling) and hydraulic modeling of the Koshi River Basin, such that the climatic data (present and from the different Regional Climate Model) would be the input for the analysis. He further emphasized that such analysis would generate the information regarding the hydrology of the basin that would very much be relevant for the flood risk reduction as well as development planning in the basin.

b. Revisiting the design standard / values of the infrastructure: the proposed Koshi High Dam: He pointed out on-going study on the Detailed Project Report (DPR) of the Koshi High Dam, and stressed the possible climate risk that needs to be considered while designing such project. He clarified that this study will be helpful in assessing the flow in future climatic scenario, that we aid into looking the Koshi High Dam.

c. Assessment of Socio-economic Vulnerability, Land Use and Exposure of critical infrastructures: Dr. Devkota also distinctly addresses the participants that the local people socio-economic conditions and their vulnerability to floods, plays an important role in the disaster risk reduction. He further highlighted the important of the assessment of socio-economic vulnerability as the area is very prone to flood disasters.

d. Contributing to policy formulation process on climate resilient development: Dr. Devkota also focused on the preparation of the results of this study in the form of the research papers in national and international journals. He highlighted that the good documentation of the this study will aid tremendously in understanding the Koshi River Basin and the local socio-economic issues that can help in policy formation process.

e. Awareness building to stakeholders including local communities and Training of new generation: He emphasized that one of the major objectives of this study is to create give opportunities to new coming reserachers/ students. He also pointed that the study has funded the six M.Sc. thesis as well as provided opportunities for young researched to work in the project. He further welcomed all the participants to look into the web-site of NDRI as NDRI always is dedicated to research and frequency announces research work opportunities. Besides, he mentioned that the study aims to create awareness regarding the results from the study.

He then addressed all the participants in providing their valuable comments/ suggestions/ view-points in the following issues:

1. What design parameters/standard be prioritized ?
2. What are the major vulnerability indicators to be assessed?
3. What are the policy questions that should be prioritized ?
4. How awareness building of stakeholders including local communities and training of new generation be made more effective?

Ultimately, he provided vote of thanks to all the participants of the workshop.

(Refer- Annex II for presentation)

3.1.3 Key points from the speech made by Chief-guest Mr. Jay Prakash Gupta, Campus Chief, Sunsari Multiple Campus

Mr. Jaya Prakash Gupta highlighted the importance of the study in the context of the development of Nepal. He initiated his speech with the definition of 'development' in Nepalese context. He also succinctly pointed out the distinction in use of word 'development' in developing countries like Nepal and developed countries. In Nepal, the development is limited to the processes of constructing the basic infrastructures, whereas the development in developed countries is about attaining the socio-economic growth. He further elaborated that the word 'development' is used when there is possibility of change; after saturation the word 'growth' is used. He further explained that the development cannot be realized in absence of the growth. He focused on our efforts to pathway of growth. He related climate change to growth of the country. He emphasized that water resources is crucial to growth of Nepal, and as the impacts of climate change will affect the water resources of the country. In the context of construction of the Koshi High Dam, he pointed out the importance of the research like this in generating information to the policy makers and local people, that will help in rational decision making process that eventually is important to attain the growth of Nepal. Finally, he heartily congratulated the principle investigator and NDRI in conducting such relevant study and wished success ahead.

Photograph 3-3: Chief-guest Mr. Jay Prakash Gupta providing remarks about the workshop

3.1.4 Key points from the speech made by Chairperson - Dr. Jaya Kumar Gurung , Secretary, Nepal Development Research Institute

Dr. Jaya Kumar Gurung first thanked the chief guest for his valuable comments on his perspective of development and the importance of research. He then focused on the difference between work and research. He mentioned that research plays an important role in the development because it brings the facts and figures from the ground level to the society so that one can better understand the truth. As such, he then focused on the importance of consultative workshop in understanding the real problems/ ground reality by providing important input to research. Dr. Gurung also expressed the need of homework in research to make it practical and very relevant to the local context. He further added that the research should address the actual problem of the local society. As such, this type of consultative workshop will give researchers the issue to look into for further study. He highlighted that this type of workshop should be continuous process and importantly two-way process. This study should address the real issues in the Koshi River Basin. Ultimately, he cordially invited all of the representatives from different concerned organizations and stakeholders to actively take part to make this research more pragmatic and fruitful.

Photograph 3-4: Dr. Jaya Kumar Gurung sharing his vote of thanks

3.2 Technical Session:

There were four technical presentations in this sessions describing the components as well as informing the participants about the current state of this research. This session also elaborated on the issues for the discussion in the feedback/consultation session. The four presentations are:

i. Application of Climate data from RCM in Koshi River Basin- by Mr. Dibesh Shrestha, Research Associate

ii. Snow Melt Runoff Modeling - by Ms. Anita Khadka, Research Associate

iii. Hydrologic modeling of the Koshi Basin - by Mr. Dibesh Shrestha on behalf of Mr. Dhiraj Gyawali, Research Associate

iv. Assessment of Socio-economic Vulnerability - by Dr. Manjeshwori Singh, Co-investigator

(Note: Refer Annex II for presentation)

3.3 Feedback/ Consultation Session:

This session was moderated by Dr. Devkota. In this session, two groups were formed by the participants for the discussions - 'Technical Team' and 'Socio-economic vulnerability assessment team' were formed by the participants. The teams carried out the discussion on the following issues:

Technical Team	Socio-economic Vulnerability Assessment Team
General Issues: 1. What design parameter/standard be prioritized ? **Specific Issues** 1. How to deal with upstream projects ? 2. Are benefits of Koshi Dam and associated risks tradable? 3. How to define cases and locations of dam break and embankment breaching ?	**General Issues** 1. What are the major vulnerability indicators to be assessed? 2. What are the major variables to considered for risk assessment (population, agriculture, major infrastructure)? **Specific Issues** 1. Weight (W) identification for considered factor for the vulnerability assessment 2. Are you satisfied with proposed survey technique, sampling, site selection, sample size etc ? 3. Are you satisfied with number of FGDs and KII? (more/less/enough)

Photograph 3-5 : Technical Team

Photograph 3-6: Socio-economic Vulnerability Assessment Team

(Refer - Annex III for list of participants)

3.4 Results from the Discussion session

3.4.1 Results from the discussion of the technical team:

In the technical group, five participants were actively engaged in the discussion. The group was headed by Er. Saroj Karki from Department of Water Induced Disaster Prevention (DWIDP). The team highlighted the following issues:

a. Proper selection/ revisiting the dam height (under the current and future scenario of the climate change): The team focused on the time in which the initial study of the Koshi High dam was carried out. He believed that the height of 269m was considered about 50 years ago; so that it do not incorporate the conditions envisioned under climate change scenarios. So, the current study on Detailed Project Report regarding the construction of the Koshi High Dam should incorporate the issues of climate change when considering the dam height.

b. Spillway Sizing: Along with the height of the dam, the team also focused on the appropriate design of the spillway in order to minimize the risk associated with the dam.

c. Dam operation rules: The team put the reference of the Gandak and Koshi Barrage regarding the operation of the barrage rules in Gandaki. The team claimed that the barrage operation in the Gandak barrage are being controlled by the Indian Government. The team members put their views that Nepal government should have the authority to control the barrage, so that it is also in favor of the Nepalese farmers and society.

d. Siltation and dead storage volume: The technical team concluded that the siltation is the major problem in the Koshi River. So, the team considers that the siltation should be seriously taken into consideration when designing the dam. The team leader gave an example of the Kulekhani Reservoir, where the cloudburst rainfall over 500mm in 24 hrs drastically reduced the dead storage of the reservoir shortening the life of the reservoir. So, the team considers that the extreme events both with or without the context of climate change scenario should be strictly taken into account.

e. Glacier Lake Outburst Flood (GLOF) and flash floods: The technical team looked into the aspect of the Glacial lakes that are present in the Koshi River Basin and referenced the events of GLOF that have taken place in the study area in different points of time. Besides, the team also reminded the flash flood that occurred in the Seti River in Pokhara. The technical team suggested to incorporate the impacts of such extreme events in the study. the team also suggested to include the snow-modeling to analysis the impacts of snow-melt processes and glacier melts.

f. Risk associated with the dams: The technical team emphasized the study should help the government in the analysis of the impacts of the disaster as in cases of the dam failure or embankment breach. The team focused that study should aid to look into the Nepal's capacity to absorb the risk associated with mega-hazard. The team also reminded that Nepal is very vulnerable to the earthquake with lots of faults in the Koshi Zone and earthquake can have devastating effect on the dam itself and the socio-economic development of the whole country.

g. Bio-diversity and socio-economy of the people: The team provided the brief look into the effect of inundation and the loss of the bio-diversity in the Koshi Basin due to dam. Besides, the team illustrated possibility of loss of livelihood source of people by providing example of the people of Bhojpur. The people of Bhojpur carry out the business of wooden logs where the transportation of the logs are basically done by flow of Koshi River.

h. Most vulnerable point of embankment: The team also suggested that the most vulnerable point in the embankment is the point in the Mahendranagar VDC. The team mentioned that at this area, the Koshi River is very active.

Besides, the team classified possible impacts of the Koshi High Dam into two categories. They are:

Benefits	**Risks**
• Electricity • Irrigation • Overall development of the area	• 269m of Dam is itself a challenge in its construction and management • Seismic zone • Siltation • Extreme events as in case of Kulekhani Dam • Bio-diversity • Compensation Issues • Local Livelihood

3.4.2 Results from the discussion of socio-economic vulnerability assessment team:

10 participants took part in the active discussion in this group. The team was led by Mr. Krishna Prasad Bhattarai of Abhiyan Nepal. Ten participants actively participated in the team discussions. The team focused on the following issues:

a. Possible affected VDC and Inundation impacts: The vulnerability team focused that if the Koshi High Dam is to be constructed, then it would affect more than 83 VDCs of the Sunsari, Udayapur, Bhojpur, Dhankuta, Panchthar, Therathum, Khotang, Okhangunga, Sankhuwasabha by the inundation and affect millions of people living in the area. He also raised the issues of inundation that occurred in Auguest 2008 and damage of the agricultural land, displacement of the local people. Moreover, he focused on the issues of the Koshi Agreement between government of India and Nepal regarding the cost that still needs to be paid by government in acquisition of the land. He also mentioned that the main problem of inundation is due to the accumulation of the sand and silts. So, current need is to have survey on this in order to know the rate of accumulation and the possible danger it brings.

b. Livelihood of the people and Irrigation: The socio-economic team considered that the livelihood of the local people as important factor to be taken into account. The team mentioned that the flood have converted thousands of hectares of agricultural land into the sand and silt, that has affected the livelihood of the local people. Besides, the team said that many times the flood have washed away the homes and livestock, yet the government has not considered it seriously. The team also pointed out that the study should look such livelihood aspect. The team also pointed that the irrigation plays important role in the agriculture of the area. So, the construction of the structure should be focused on the irrigation.

c. Loss of the religious and cultural diversity: The team pointed that there are local people of different ethnicity and religion in the area with diverse culture and religious practices. So, the team highlighted that the construction of the dam as well as its possible breaching would cost into the loss of such important aspects of people as well as Nepal.

d. Loss of bio-diversity: The team discussed about the variety of flora and fauna the Koshi River supports in the area. The team mentioned that Koshi Tappu Wildlife Reserve in very rich in bio-diversity. So, the team explained that the construction of dam will cause irreversible damage to bio-resources of the Koshi as well as of the whole country. They also mentioned about the various fish species as well as dolphins will be lost.

e. Seismic Analysis of the area: The team mentioned that Nepal is very prone to earthquake. So, any high earthquake can destroy the structures as dam and the devastation that it will cause would be beyond the absorbing capacity of the country.

f. Creating awareness to the people: The team pointed out that the local people should decide whether there is need of the high dam or not. So, the people should be clearly explained about both the positive and negative aspects of the dam; including the socio-economic as well as political scenario. The process should be transparent as well as the documents should be kept available, not the present condition where everything is carried covertly. It should be in simple form as that even local people can understand it, so that they can decide for themselves.

g. Control of Nepal: The team suggested that the Nepal should have equal investment in the construction of dam. The control mechanism should be in Nepalese hand. Besides, the study should also come from the Nepalese perspective so that it can clearly put the Nepalese issues. Besides, there should be equal benefit sharing.

The team also mentioned that study will help to quantify the issues and provide the research based input that will be very helpful to Nepal. The team also focused on the consideration of above points to be studied in this research.

4 Annexure

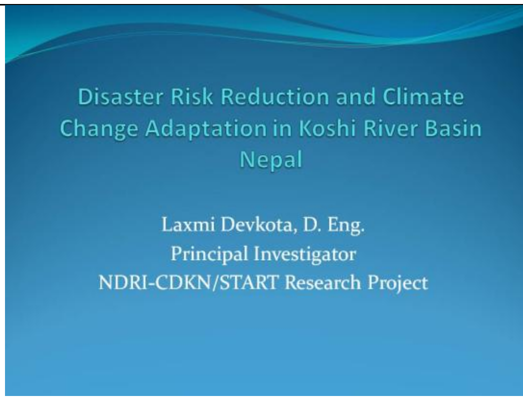
Annex I: List of participants

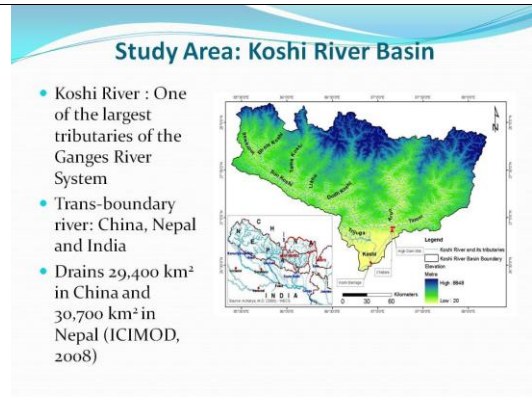
Government agencies			
S.N.	**Name**	**Institution**	**Position**
1	Chandramani Mandar	DDC, Saptari	Engineer
2	Dibya Raj Dhakal	DOI-No.2	Nayab subba
3	Dr. Kamal Giri	DLSO, Inaruwa	Veteniary officer
4	Ganesh Prashad Pokharel	DADO, Sunsari	J.T.
5	Govind Chilwal	Sunsari Multiple Campus	Lecturer
6	Jai Prakash Gupta	Sunsari Multiple Campus	Campus Chief
7	Kishor Prashad Shah	DTO, Saptarai	Engineer
8	Rajendra Dhungana	KTWLR	Conservation officer
9	Rudra Naryan Mehta	DDC, Sunsari	

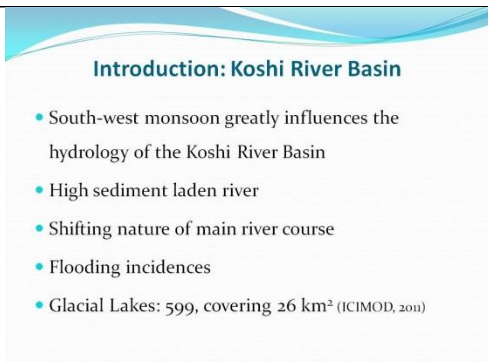
Non-government agencies			
S.N.	**Name**	**Institution**	**Position**
10	Dev Naryan Yadav	KVS, Saptari	Team Leader
11	Dibesh Shrestha	NDRI	Research Associate
12	Ganesh Prashad Timsina	Saptakoshi Samitee	Section officer
13	Jaya Kumar Gurung	NDRI	Secretary
14	Krishna Prashad Bhattarai	Abhiyan Nepal	Secretary
15	Kusum Lal Yadav	NCDM	Conveyer
16	Julia Landriev	CNRS (Scientific Research Center kof France)	Student
17	Laxmi Prashad Devkota	NDRI	PI
18	Manjeshwori Singh	NDRI	Co-Investigator
19	Puspa Bhattari	NGOCC/Save the Earth	Chairman
20	Raj Naryan Chaudahry	PMC, Sunsari	Supervisor
21	Sanjeev Shreshta	Plan Nepal, Sunsari	WASH PC
22	Saroj Karki	DWDIP, Biratnagar	Engineer
23	Anita Khadka	NDRI	Research Associate

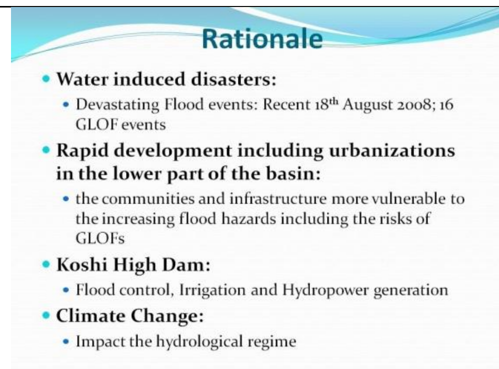
Annex II: Presentations

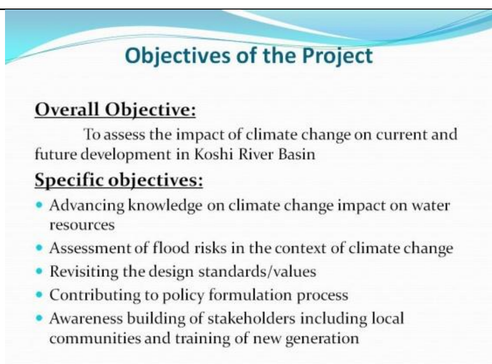
1. Introduction of the research project by Dr. Laxmi Prasad Devkota, the Principal Investigator

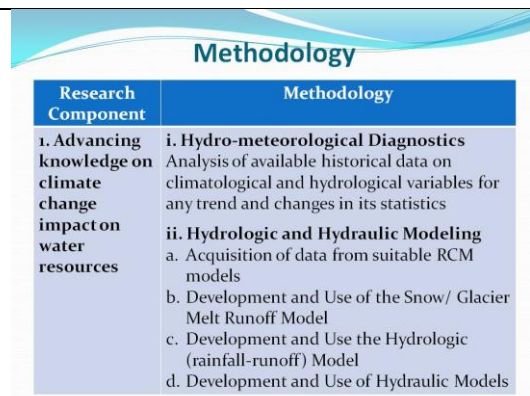




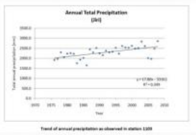




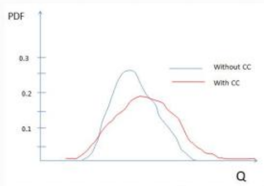




Hydro-meteorological Diagnostics



Trend Analysis



Change in Statistics

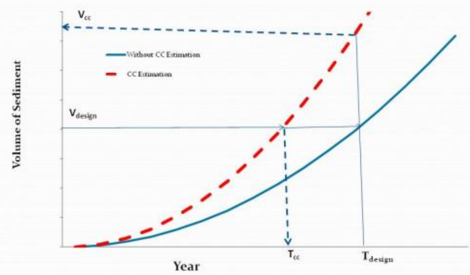
Modeling

SN	Activities	Models
1	Acquisition of Climate Change Data	RCM (PRECIS, REGCM3, WRF)
2	Snow melt Runoff	WinSRM
3	Rainfall-Runoff	SWAT
4	Sediment Yield	SWAT
5	Inundation and Flood Analysis	HEC-RAS

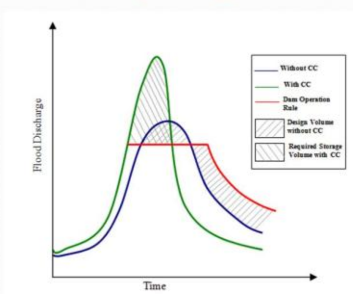
Methodology (contd.)

Research Component	Methodology
2. Revisiting the design standard / values of the infrastructure: the proposed Koshi High Dam	Results of the hydrologic, hydraulic and sediment transport modeling will be used to a. Analyze the design parameters / values of the reservoir with climate change scenario: Capacity of Dam b. Access the climate change Risk: Dam breaking, Water availability

Design Values



Operation Rule/Design Value



Methodology (contd.)

Research Component	Methodology
3. Assessment of Socio-economic Vulnerability, Land Use and Exposure of critical infrastructures	**Risk = Hazard x Exposure x Vulnerability** **Hazard:** Flood Hazard Map- **Modeling Result** **Exposure:** Population, Agricultural and Industrial Area – **Field Survey & Census** **Vulnerability :** Demographic, economic and social characteristics & degree of preparedness and recovery capacity (Eidsvig, 2011)- **Field Survey**

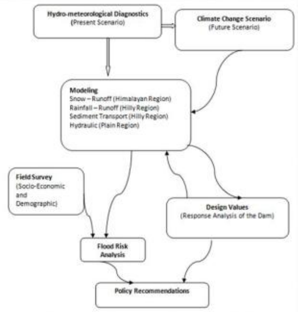
Methodology (contd.)

Research Component	Methodology
4. Contributing to policy formulation process on climate resilient development	•Research result dissemination workshops •Hazard, vulnerability and risk maps will be helpful to the planners to take decisions

Methodology (contd.)

Research Component	Methodology
5. Awareness building to stakeholders including local communities and Training of new generation	•**Stakeholders' consultations/ workshops** ❖ Two feedback workshops in study area ❖ One feedback and one dissemination workshop in Kathmandu •**Inclusion of** ❖ 3 research associates and ❖ 5 master's level thesis students

Approach in Summary



Outputs, Outcomes and Impacts

Expected Impacts :

- Reduction on climate related disasters and consequent losses from current and future water resources development works in the Koshi River Basin
- Formulation of better policy related to DRR and CCA

Specific Outputs:

- Models to assess the climate change impacts
- Hazard, Vulnerability and Risk Maps
- Policy recommendations at national and community levels for DRR and CCA
- Awareness Buildings of the concerned stakeholders
- Capacity building of young researchers
- Publication of peer-reviewed journal articles

Study Team

A. Investigators: 4 Persons
PI: Dr. Laxmi Devkota
CI: Dr. Manjeshowri Singh
CI: Dr. Sunil Babu Shrestha
CI: Dr. Rijan B. Kayastha

B. Research Associates 3 Persons
Mr. Dibesh Shrestha
Mr. Dhiraj Gyawali
Ms. Anita Khadka

C. Thesis Students: 5 Persons
Mr. Surya Narayan Shrestha
Ms. Gunjan Silwal
Mr. Jeevan Chhetri
Mr. Mahesh Chaulagain
Mr. Rekha Uprety

Responsibilities of PI/CI/RA

SN	Position	Name	Main Responsibilities	Responsible to
1	PI	Dr. Laxmi Devkota	Overall execution of the study Flow and Sediment hydrology and hydraulics	
2	CI	Dr. Manjeshowri Singh (Ms)	Socio-economic vulnerability	
3	CI	Dr. Sunil Babu Shrestha	Climate change policy	
4	CI	Dr. Rijan Bhakta Kayastha	Snow and glacier hydrology	
5	RA	Mr. Dibesh Shrestha	Generation of Projected Climate Data	Dr. Divas Basnyat Dr. Laxmi Devkota
6	RA	Mr. Dhiraj Gyawali	Hydrologic and Hydraulic Modeling	Dr. Laxmi Devkota
7	RA	Ms. Anita Khadka	Snow Runoff Modeling and Socio-economic Analysis	Dr. Rijan Kayastha Dr. Manjeshowri Singh Dr. Laxmi Devkota

Thesis Students and their Thesis Titles

SN	Name of the Student	Theme	Title	Gender	Subject/Faculty	Responsible to	Remarks
1	Surya Narayan Shrestha	Climate Downscaling/ Development and use of Rainfall Runoff Model	Effect of Climate Change on the Multipurpose Koshi High Dam Project	M	Water Resources Engineering/Institute of Engineering	Dr. Divas B. Basnyat Dr. Laxmi Devkota	ED/NDRI PI
2	Gunjan Silwal	Development and use of Snow Runoff Modeling	Modelling Snow and Glacier Melt Runoff and Impacts of Climate change: A case Study of Koshi Basin, Nepal	F	Environmental Science/Central Department of Environmental Science	Dr. Rijan B. Kayastha Dr. Laxmi Devkota	CI PI
3	Jeevan Chhetri	Flood induced Socio-economic vulnerability	Flood Induced Socio Economic Vulnerabilities of Climate Change and Local Coping Mechnism in the Koshi River Basin	M	Environmental Science/College of Applied Sciences	Dr. Manjeshori Singh Dr. Laxmi Devkota	CI PI
4	Mahesh Chaulagain	Climate change Vulnerability, and Adaptation Policy	Perception of People of Koshi River Basin on Climate Change and Adaptation Policies	M	Natural Resources Management/Nepal Engineering College	Dr. Laxmi Devkota Dr. Manjeshori Singh	PI CI
5	Rekha Uprety	Climate Change Policy and Strategies	Climate Change, Adaptation Strategies and Policy in Koshi Basin	F	Sociology/Central Department of Sociology	Dr. Sunil B. Shrestha Dr. Laxmi Devkota	CI PI

Steering Committee

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Funded by:
Climate and Development Knowledge Network (CDKN) and
Global Change SysTem for Analysis, Research and Training (START)

Some Issues for Feedback

1. What design parameters/standard be prioritized ?
2. What are the major vulnerability indicators to be assessed?
3. What are the policy questions that should be prioritized ?
4. How awareness building of stakeholders including local communities and training of new generation be made more effective?

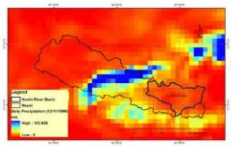
How to connect this research with local and national policy ?

Thank You Very Much !

ii. Application of Climate data from RCM in Koshi River Basin- by Mr. Dibesh Shrestha, Research Associate

Nepal Development Research Institute

"Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal"



Application of Climate data from RCM in Koshi River Basin

Presented by:

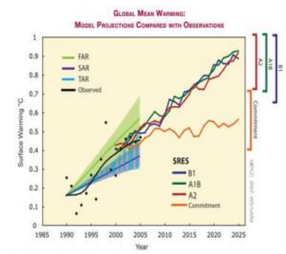
Dibesh Shrestha

M.Sc. In Interdisciplinary Water Resources Management

Research Associate, NDRI

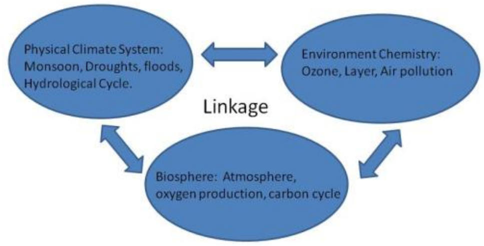
Climate and Climate Change

- Climate is the average condition of the atmosphere, ocean, land surfaces and the ecosystems that dwell in them.
- Weather is the state of the atmosphere and ocean at a given moment in time.
- Climate Change: Change in the average condition.



Climate Model

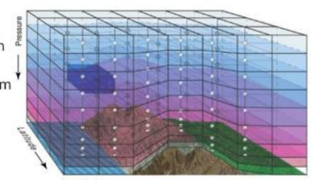
- Climate model is the mathematical representation of climate system.
- Climate System:



Climate Model

- The atmosphere is divided into a finite number of grid-cells in the vertical and horizontal cells

Representation of the physical processes of the climate system using the principles of:
- Conservation of the momentum
- Temperature equation
- Continuity equation
- Pressure Law



- Global Circulation Model (GCM)

Global Scale, coarser resolution 300 – 500 km

- Regional Climate Model (RCM)

Small region focused, spatial resolution 12-25 km

IPCC Scenarios

Economic emphasis →

A1 storyline	A2 storyline
World: market-oriented Economy: fastest per capita growth Population: 2050 peak, then decline Governance: strong regional interactions; income convergence Technology: three scenario groups: • **A1FI**: fossil intensive • **A1T**: non-fossil energy sources • **A1B**: balanced across all sources	World: differentiated Economy: regionally oriented; lowest per capita growth Population: continuously increasing Governance: self-reliance with preservation of local identities Technology: slowest and most fragmented development
B1 storyline	**B2 storyline**
World: convergent Economy: service and information based; lower growth than A1 Population: same as A1 Governance: global solutions to economic, social and environmental sustainability Technology: clean and resource-efficient	World: local solutions Economy: intermediate growth Population: continuously increasing at lower rate than A2 Governance: local and regional solutions to environmental protection and social equity Technology: more rapid than A2; less rapid, more diverse than A1/B1

← Environmental emphasis

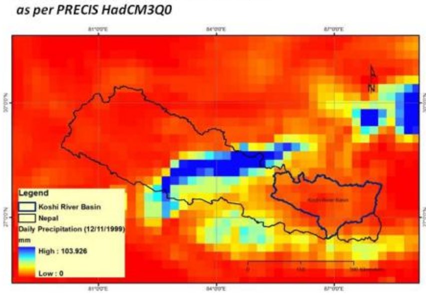
↑ Global integration

Regional emphasis ↓

Source: IPCC AR4 2007 **Figure TS.2.** *Summary characteristics of the four SRES storylines [F2.5]*

Climate Change Projection Data in Nepal

Daily precipitation (in mm) of 12/11/1999 as per PRECIS HadCM3Q0



Data Source:
Department of Hydrology and Meteorology

6

Climate Change Projection Data in Nepal

- Regional Climate Model (RCM Data) in Nepal

Nepal Climate Data Portal (By Department of Hydrology and Meteorology)

RCM	PRECIS	WRF	RegCM4
Parent GCM	HADCM3Q0, ECHAM05	Era40, ECHAM05, GFDL2, CCSM, HadCM3	ECHAM05 and ECHAM04
IPCC Scenario	A1B	A1B	A1B and A2
Validated period	1970-2000	1970-2000	1970-2000
Downscaled period	2020-2060	2020-2060	2020-2060
Horizontal Resolution	25 km	12 km	20 km
Temporal Resolution	Daily	Daily	
Variables	Rainfall, Temperature (Mean, Max and Min), RH, Ground Speed, Sea Level Pressure	Rainfall, Temperature (Mean, Max and Min), RH, Ground Speed, Sea Level Pressure	Rainfall, Temperature (Mean, Max and Min), RH, Ground Speed, Sea Level Pressure

Source: Technical Approach and Methodology for Projected Data Preparation, DHM 7

Bias Correction

- Bias is basically deviation between simulated value and observed value
- Different methods of Bias Correction:
- Gamma transformation method: Hay et al. (2002) the corrected precipitation data did not contain the day-to-day variability which was present in the observed data set.
- Linear correction Approach: Adjusts the mean precipitation, but leaves the CV unaffected, because both mean and standard deviation are multiplied by the same factor (Leander and Buishland, 2007).
- Hybrid quantile method
- Power transformation method:
  - Relatively simpler to apply than gamma method
  - Corrects the CV of the data
  - Our assumption: In case of Nepal, the method should preserve the day-to-day variability of the precipitation (should be examined during this study)

8

Power Transformation Method of Bias correction

- Non-linear method
- Corrects the Coefficient of Variation and Mean
- $P_{corr} = a \times P^{b}$

Where,

P_{corr} = Bias corrected daily precipitation amount

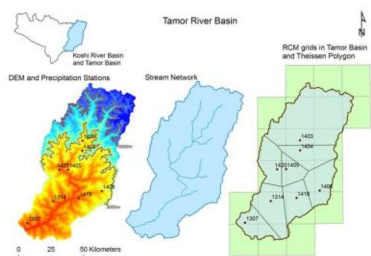
P = Uncorrected RCM daily precipitation amount

b = Parameter corresponding to CV of the observed daily precipitation

a = Parameter corresponding to mean of the observed daily precipitation

Application to Koshi River Basin

- Sub-basin wise bias correction
- Application to Tamor River Basin
- RCM: PRECIS HadCM3



Results from Bias Correction

Example: Station 1405

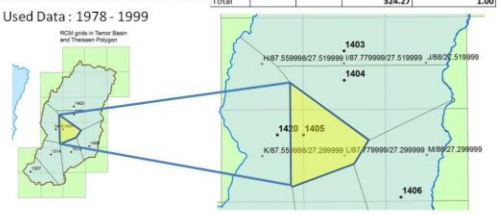
Observed Data Available:

1978 to 2008

RCM Data available: 1970 to 1999

Used Data : 1978 - 1999

Grid_ID	Latitude	Longitude	Area (sq.km)	Contributing Factor
H	27.519999	87.559998	20.63	0.064
I	27.519999	87.779999	14.32	0.044
K	27.299999	87.559998	68.46	0.211
L	27.299999	87.779999	220.86	0.681
Total			**324.27**	**1.00**



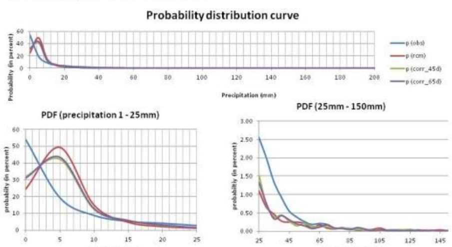
Comparison: Descriptive Statistics

- Descriptive Statistics

Descriptive Statistics	***Pobs***	***Prcm***	***Pcorr_1405_45d***	***Pcorr_1405_65d***
Mean	5.56	5.14	4.71	4.72
Standard Error	0.13	0.16	0.12	0.12
Standard Deviation	11.58	14.35	10.61	10.89
Sample Variance	134.10	205.80	112.62	118.49
Kurtosis	19.35	342.90	47.52	56.46
Skewness	3.64	13.35	5.77	6.24
Range	134.70	557.67	154.09	177.79
Minimum	0.00	0.00	0.00	0.00
Maximum	134.70	557.67	154.09	177.79
Sum	44681.70	41339.18	37851.65	37935.79
RMSE		11.86	18.74	14.51

Comparison: Probability distribution

- Probability distribution curve



Thank you!

iii. Snow Melt Runoff Modeling - by Ms. Anita Khadka, Research Associate

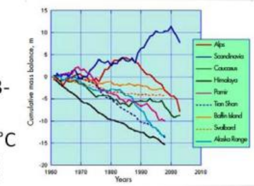
"Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin", Nepal

SNOW MELT RUNOFF MODELING

ANITA KHADKA
NDRI

SIGNIFICANCE OF SNOW MELT RUNOFF MODELING

- Glaciers of Himalaya receding faster than the world average (Thompson, 2007)
- Decrease of snow cover by 43-81% in 2100 if the annual mean temp. increased by 1-6°C (Bohner and Lekmkhul, 2005)
- There is a prediction of increase in annual river discharge until around 2030 and then decrease because of rapid melting of snow and glacier in the beginning (IPCC, 2007).



SIGNIFICANCE Cont….

- Snowmelt model allows to understand the physical processes of snow accumulation, snowmelt and runoff
- Assess the contribution of snow/ glacier cover area in basin hydrology
- To understand the future of snow fed rivers in due to change in snow parameters in the context of Climate Change

IMPORTANCE IN KOSHI BASIN

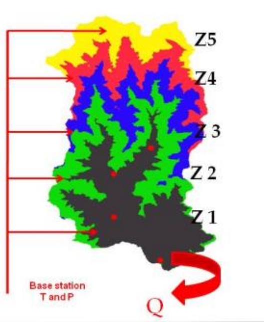
- 843 glaciers with total area of 1180 sq.km (2nd largest in terms of area coverage after Gandaki)

Glacial lakes				
Basin	Total No.	% of total	Area (sq. km)	% of total
Koshi	599	40.86	25.958	40.07
Gandaki	116	7.91	9.538	14.72
Karnali	742	50.61	29.147	45
Mahakali	9	0.61	0.137	0.21
Total	1466		ICIMOD, 2011	

- Koshi river had showed a decreasing trend of discharge during low flow season from 1947 – 1994 (Sharma et. al. 2000).

MODEL CONCEPT

- Basin divided into elevation zones (max. of 16 zones)
- P and T extrapolated in each zone
- Snowmelt calculated in each zone
- Runoff generated added from each zone
- Total runoff routed through single outlet



SRM INPUT

- Variables

Temperature | Precipitation | Snow cover area

- **Parameters**
  - Degree day factor (a)
  - Runoff coefficient (Cs & Cr)
  - Recession coefficient (k)
  - Temp. Lapse rate (γ)
  - Critical temperature (Tcrit)
  - Rainfall contributing area(RCA)
  - Time lag (L)

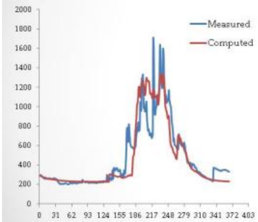
STUDY BASIN

- 6 sub-basins of koshi rive basin
- Basin divided at an interval of 600m

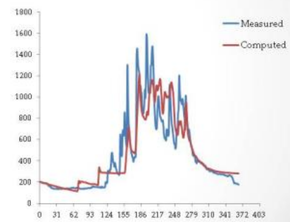
Sub-basins	Area (km^2)	Elevation (m)	Area >4500
Tamor	4,002	358-8387	1.410
Arun	26,271	879-8776	21,360
Dudhkoshi	3,713	432-8746	1,670
Likhu	851	519-6855	120
Tamakoshi	2,925	797-7311	1,750
Sunkoshi	3,592	595-7938	1,810

TEST RUN

- Arun River Basin
- Outlet point: Uwa gaon; station id: 600.1



Calibrated year 2005
$R^2 = 0.79$; Dv = 3.204%



Validated year 2006
$R^2 = 0.76$; Dv = 1.183%

WAY FORWARD

- Calibration will be done from the year 2000 to 2008
- Future scenario for snowmelt runoff will be estimated using downscaled Temperature and Precipitation data for the period 2030 to 2059

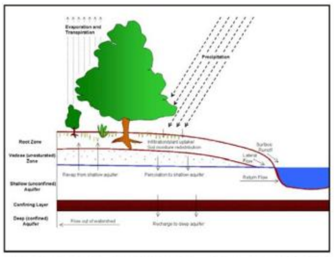
THANK YOU

iv. Hydrologic modeling of the Koshi Basin - by Mr. Dibesh Shrestha on behalf of Mr. Dhiraj Gyawali, Research Associate

Nepal Development Research Institute (NDRI)

NDRI

"Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal"



HYDROLOGIC MODELING OF THE KOSHI BASIN

Presenter: Dhiraj Raj Gyawali, NDRI-CDKN-START Team

Nepal Development Research Institute (NDRI)

NDRI

HYDROLOGICAL ANALYSIS

- Major Activities:
  - To integrate various climatological, topographical and landuse/soil parameters to develop a hydrological model for the Koshi Basin.
  - To assess the sediment yield at the basin outlet
  - To assess the impact of changes in climatic scenarios on the hydrology and sediment yield of the basin.

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Models and Softwares used

- Soil and Water Assessment Tool (SWAT):
  (Arc SWAT 2009)
  - For hydrologic modeling, and
  - sediment yield modeling

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SWAT: Model Description

- River basin scale model developed to quantify the impact of climate and land management practices in large complex watersheds, on hydrology and sediment.
- Semi-Physically based, semi – distributed model.
- Conceptually, SWAT divides a watershed into sub-watersheds. Each sub watershed is connected through a stream channel and further discretized into Hydrologic Response Unit (HRU).
- HRU is a unique combination of soil and vegetation type in a sub watershed, and SWAT simulates soil water content, surface runoffs, sediment yield, and management practices at the HRU level and aggregated by a weighted average.
- Runoff and Sediment loads are predicted separately for each HRU and routed to obtain the total runoff and sediment load for the watershed at the outlet.

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Model Components

- Hydrological Component
  - Land Phase: Water Balance Equation
  - Routing Phase
- Sediment Component
  - Erosion by Rainfall and Runoff (MUSLE)
  - Sediment Routing

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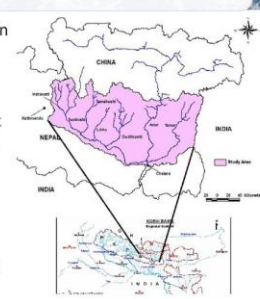
NDRI

Study Area

- Area considered: the Koshi Basin upstream of Chatara within Nepal
- Elevation: 108 m at Chatara to more than 8,000 m in the Great Himalayan Range including Mt. Everest (8848 metres)
- Maxm. Precipitation at around 1500 masl.
- Avg Annual flow and sediment yield: 1409 cumecs, 170 million tons, (Galay et. al, 2003)

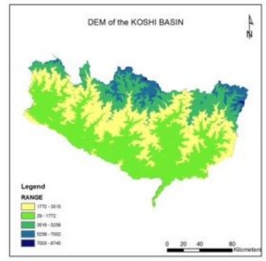


Input Data

- **Spatial Data**
  - Digital Elevation Model (Aster DEM)
  - Land Use Map (*Source: Department of Survey*)
  - Soil Map and Soil Properties (*Source: FAO Soil Map and Soil Database*)
- **Time Series Data** (*Source: Dept. of Hydrology and Meteorology*)
  - Meteorological data (Rainfall , Maximum and minimum Temperature, Relative humidity, Sunshine hours, Wind speed) for Weather generating Stations
  - Meteorological data (Rainfall and Temperature) for Weather Stations
- **Flow and Sediment data at the outlet:** For calibration and validation

Input Data (Contd.)

- Topographical Data (Aster GDEM v 2.0*)



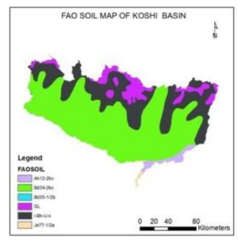
*Aster GDEM is a property of METI and NASA

Input Data (Contd.)

- Landuse Data (*Source: Department of Survey*)

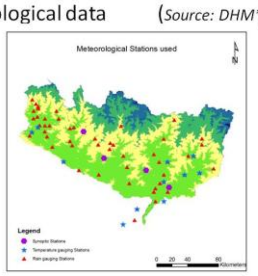
Input Data (Contd.)

- Soil Data (*Source: FAO soil Map & Soil property Database)*)



Input Data (Contd.)

- Meteorological data (*Source: DHM**)

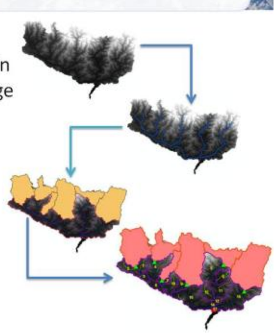


**Department of Hydrology and Meteorology*

METHODOLOGY

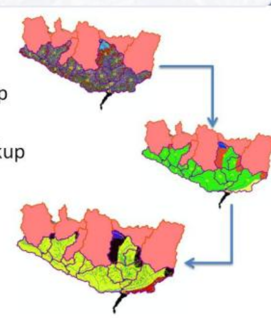
MODEL SETUP

- Watershed Delineation
- Initial Stream and subbasin outlets definition: Drainage area threshold approach
- Addition of the basin outlet: Chatara
- Addition of Inlet Points
- Basin Delineation and calculation of basin parameters.



MODEL SETUP (contd.)

- HRU Analysis
  - Landuse map with corresponding Lookup table
  - Soil map and soil lookup table
  - Multiple slope discretization
  - HRU overlay



MODEL SETUP (contd.)

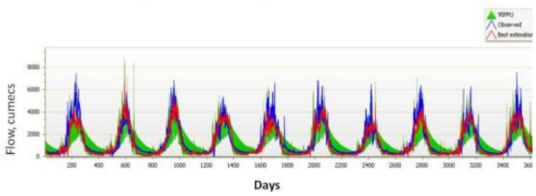
- Importing Climatic data
- Inlet flows addition,
  - Tamor: *Majhitar, Stn ID: 684*
  - Arun: *Uwa Gaon, Stn ID: 600.1*
  - Dudhkoshi: *Rabuwa Bazar, Stn ID: 670*
  - Likhu: *Sangutar, Stn ID: 660*
  - Tamakoshi: *Busti, Stn ID: 647*
  - Sunkoshi: *Pachuwarghat, Stn ID: 630*

MODEL SETUP (contd.)

- Warm up Period: 1976 – 1985
- Calibration Period: 1991 – 2000
- Validation Period: 2001 – 2005

Calibration (1991 – 2000)

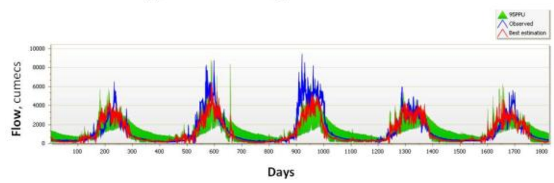
- SUFI-2 Algorithm using SWAT-CUP



CALIBRATION SUMMARY	
NSE	R^2
0.80	0.81

Validation (2001-2005)

- SUFI-2 Algorithm using SWAT-CUP



VALIDATION SUMMARY	
NSE	R^2
0.75	0.77

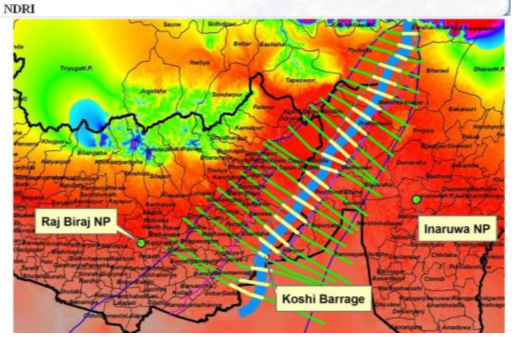
Way Forward

- Calibration and validation of sediment yield at the outlet
- Incorporation of the projected RCM data into the calibrated hydrologic model to calculate the flows and sediment yield for forecast period.
- Calculation of the flow statistics for the forecast period
- Hydraulic Analysis

Hydraulic Analysis

- Pre-Ras Application (TIN Model, Flow Paths, C/S, Banks and Levees) using Hec- GeoRAS
- 1D Flow Model using HEC-RAS
- Post Geo-Ras Application
- Flood Prone Area Delineation: Dam and Embankment Breaching Cases

Hydraulic Modeling using HEC-RAS



THANK YOU

v. Assessment of Socio-economic Vulnerability - by Dr. Manjeshwori Singh, Co-investigator

Assessment of Socio-economic Vulnerability

Disaster Risk Reduction and Climate Change Adaptation in Koshi River Basin, Nepal

By

Manjeshwori Singh, Ph.D.
Co-investigator, NDRI- CDKN/START Study Team

(February 22, 2013)

1

Contents

1. Introduction
2. Socio-economic Survey
3. Socio-economic Vulnerability Assessment
4. Indicators for Socio-economic Vulnerability Assessment
5. Vulnerability Index Estimation

Introduction

- One of the components of the study is Assessment of Socio-economic Vulnerability of the study area.
- It helps to identify the vulnerable areas.
- It is required for the assessment of the Flood Risk Zoning

  R = H X E X V

  (Where, R= Risk, H= Hazard, E= Exposure, V= Vulnerability)
- It will useful for making flood disaster risk reduction policies/strategies so that risk can be minimize.

3

Socio-economic Survey

Methodology:

i. Survey Techniques

1. Household Survey (HS)
2. Focus Group Discussion (FGD)
3. Key Informant Interview (KII)

4

Household Survey

ii. Sample Size:

Total Sample Size= **384 HHs**

(For large population if total population above 100,000, 384 HHs will be taken as total sample population at 95% CL & 5% CI)

iii. Site Selection:

Districts Selection (Purposively): **Sunsari & Saptari**

(Highly flood prone districts-, NAPA, 2010)

5

Household Survey cont...

Area Clustering : (Koshi flood, August 2008 or Flood hazard map based on 100 years flood?

Area	Clusters
1. Highly affected area	C1
2. Moderately affected area	C2
3. Less affected areas	C3

6

Household Survey cont…

iv. Sample Distribution:

Population proportionate sampling
HH Selection: Random

v. Sample Design:

Semi-structure questionnaires & Checklist

Household Survey cont…

2. Focus Group Discussion (FGD):
   At least one FGD in each cluster.
   Total FGDs = 6

3. Key Informant Interview (KII):
   5 KII in each cluster = 15
   KII (national level) = 5
   Total KIIs = 20

Socio-economic Vulnerability Assessment

Factors considered for the Assessment;

- Demography
- Economy
- Social Aspect
- Preparedness
- Recovery

Indicators for Socio-economic Vulnerability Assessment (Eidsvig, 2011)

Indicatiors	Weights (Range 1-3)	Criteria for Indicator Ranking (1: Low vulnerability and 4 high vulnerability)
Demographic Indicators (weight: w_1, Value: V_1)		
Age distribution	1	1. Less than 20% population aged less than 10 years and above 65 years and disabled population 2. 20-30% population aged less than 10 years and above 65 years and disabled population 3. 30-50% population aged less than 10 years and above 65 years and disabled population 4. More than 50% population aged less than 10 years and above 65 years and disabled population
House Type (based on roof type)	2	1. RCC 2. GI/Asbestos sheet 3. Clay/tiles 4. Thatched roof

Indicators….

Indicators	Weights (Range 1-3)	Criteria for Indicator Ranking (1: Low vulnerability and 4 high vulnerability)
Economic Indicators (weight: w_2, Value: V_2)		
Income	3	1. Greater than $ 2 per capita per day 2. Between $ 1-$2 per capita per day 3. Between $ 0.5-$1 per capita per day 4. Less than $ 0.5 per capita per day
Land holding	2	1. Less than 20% population is dependent on agricultural land for primary source of income 2. 20-40% population is dependent on agricultural land for primary source of income 3. 40-60% population is dependent on agricultural land for primary source of income 4. Above 60% population is dependent on agricultural land for primary source of income

Indicators cont…

Social Indicators(weight: w_3, Value: V_3)		
Education level	2	1. More than 50% is literate 2. 40%-50% population is literate 3. 30%-40% population is literate 4. Less than 20% population literate
Access to communication	3	1. Access to more than one unit of telephone/mobile 2. Access to at least one unit of telephone/mobile 3. Not access to telephone/mobile in own home 4. No telephone/mobile in the community
Mobility	1	1. Access to private car 2. Access to motorbike 3. Access to cycle 4. None
Market facility	2	1. Less than 1 km distance 2. Within 2 km distance 3. Within 2-4 km distance 4. More than 4 Km distance
Drinking water	3	1. Access in own house 2. Access in neighbor's house 3. Available in community 4. None

Indicators cont…

Preparedness Indicators(weight: w_4, Value: V_4)		
Hazard Evaluation	2	1. Community based detailed map available 2. Basic map available 3. Map under preparation 4. No
Emergency response	2	1. Good transportation (road) and organized response group in place 2. Good transportation or organized response group in place 3. Self-organized local group only 4. None
Early warning system	3	1. Advanced (24 hrs Radio, TV, Automatic siren, 1 day ahead) 2. Average (24 hrs Radio, TV, Manual Siren, same day) 3. Basic (Telephone, Mike) 4. None
Evacuation place	2	1. Less than 1 km distance 2. 1-2 km distance 3. Greater than 2 km distance 4. None
Insurance (life/property/any kind of insurance)	1	1. Life and all Property 2. Life of > 50% family members 3. Life of < 50% family members 4. None
First aid services	1	1. Adequate and in own home 2. Adequate and in community level 3. Limited 4. None

Indicators cont...

Indicators	Weights (Range 1-3)	Criteria for Indicator Ranking (1: Low vulnerability and 4 high vulnerability)
Recovery Indicators (weight: w_5, Value: V_5)		
Health institution	2	1. Less than 1 km distance. 2. 1-2 km distance 3. 2-4 km distance. 4. More than 4 Km distance.
Disaster fund	2	1. Both local level and government 2. Local and non-government level 3. Local only 4. No

Vulnerability Index Estimation

The level of vulnerability is estimated as;
e.g. Calculation of Demographic indicator

$$v_1 = \frac{w^1v^1 + w^2v^2 + w^3v^3 + w^4v^4}{w^1 + w^2 + w^3 + w^4}$$

Vulnerability Index (V) is estimated as;

$$V = \frac{W_1v_1 + W_2v_2 + W_3v_3 + W_4v_4 + W_5v_5}{W_1 + W_2 + W_3 + W_4 + W_5}$$

THANK YOU VERY MUCH!

Annex III. List of Participants in different teams

a. Technical Team

Group I	Technical Team	
S.N.	Name	Institution
1	Chandramani Mandar	DDC, Saptari
2	Ganesh Prashad Pokharel	DADO, Sunsari
3	Kishor Prashad Shah	DTO, Saptarai
4	Sanjeev Shrestha	Plan Nepal, Sunsari
5	Saroj Karki	DWDIP, Biratnagar

b. Socio-economic Vulnerability Assessment Team

Group II	Socio-economic Vulnerability Assessment Team	
S.N.	Name	Institute
1	Dev Naryan Yadav	KVS, Saptakoshi
2	Dibya Raj Dhakal	DOI-No.2 Division
3	Ganesh Prashad Timsina	Saptakoshi Samitee
4	Govind Chilwal	Sunsari Multiple Campus
5	Julia Landriev	CNRS (Scientific Research Center of France)
6	Kamal Giri	DLSO, Inaruwa
7	Krishna Prashad Bhattarai	Abhiyan Nepal
8	Kusum Lal Yadav	NCDM
9	Puspa Bhattari	NGOCC/Save the Earth
10	Raj Naryan Chaudahary	PMC, Sunsari